Blueprint Roadmapping Workshop

Las Vegas
Nevada

September 21- 22, 2000

Safety Focus Group

Strategic Issues

Education of John Q. Public

Integrated System Design

Comprehensive Data Base

Detection and Verification

Operations, Maintenance, and Training (OMT)

Strategic Issues

Education of John Q. Public

- Mitigation of public fear
- Instill a familiarity with Hydrogen as with HC fuels
  - Basic safety
  - Put H_2 into everyday life
- Areas of Concern
  - Transportation
  - Refueling
  - Storage (Station or on board)
    - Cryogenic, High Pressure, Hydrides
  - Transportation Usage
    - Collision

TO DO
Results by ‘03

Education of John Q. Public

- Crash tests to show 100% safety - leverage OEM activities
- H_2 systems compared to conventional systems with conventional fuels
- Safety Demonstration
  - hands on toys or devices
  - Spectacular safety demonstration -
    - the inverse Hindenberg problem

TO DO
Results by ‘03

Education of John Q. Public - Measured improvement

- RFP ‘01 to:
  - Compare H_2 systems to conventional systems
    - 1 year
  - Post, advertise, distribute, educate
  - Develop safety hands on toys or devices
    - put H_2 in the faces of John Q. Public
  - Develop a focus group activity that (National Lab Executed)
    - identifies relevant educational issues and opportunities
      - Transportation, refueling, storage ---
      - Task groups include all relevant groups, SAE, OEM’s, Industrial component suppliers, etc.
    - Results expected ‘03 and beyond.

Strategic Issue

Integrated System Design

- A large scale integrated systems approach is needed
  - For example; the refueling station needs to be compatible with many different onboard storage technologies
- No technical show stoppers identified today
  - Indeed, a general consensus that we know how to design systems minimizing risk and providing user friendly interfaces - the procedures are well established
  - However, this has not been done for H_2 systems.
- There is a need to identify all of the relevant issues and the necessary hazards mitigation.
- Build consensus among all stake holders
- Draft Codes and Standards

TO DO
Results by '03

Integrated System Design

- '01 - Draft a task force to identify and define relevant component and systems stake holders that will be members of a task force that will in '01.5
  - Define the technical hardware related issues relevant to safety.
    - Materials compatibility for component integration
    - H_2 detection when, where and how
    - safe systems designs for John Q. Public
  - Consensus building
  - Input for Codes and Standards - define interim C&S
- '01 - Design exercise for a "safe" integrated system - build & verify
  - Field verification facility (See Detection and Verification)
- '03 - Initial infrastructure in place built to interim C&S Standards

Strategic Issue

Data Base

- A comprehensive living data base of hydrogen related information is needed, taken in context of H_2 systems.
  - flammability limits alone are misleading, combustion limits must be taken in context of other properties like diffusivity and buoyancy
  - Physical properties, design guidelines, materials compatibility, handling, related safety issues, testing / detection, lessons learned, and hydrogen applications world wide.
- Identification of data gaps
- Fill these gaps

TO DO
Results by '03

Data Base

- '01 - RFP to develop a comprehensive WEB site - knowledge map.
  - Sustainable technical webmaster
  - Living document / depository for all H_2 relevant information.
    - Technical resource as opposed to general informational.
  - Resource to define current state of the art in practices and technologies -- living hand book for H_2 systems
  - Resource to post lessons learned
  - Resource for regulatory and insurance industries
  - etc.

Strategic Issue

Detection and Verification

- Sensor *systems* that are tolerant to “every day environments”
  - Organic compounds, PM, H_2S, CO, Soot, HAPS, dirt, temperature extremes, high accelerations --
  - Fault tolerant - false alarms are as important as non-detects
- Effective H_2 collection
- Flame detection in every day life -- near other hot objects.
- Hydrogen storage system status -- cryogenic H_2 level sensor, hydride fill gage --

TO DO
Results by ‘03

Detection and Verification

- RFP ‘01 -- Develop a field verification facility
  - test and evaluation
    - sensor technology and systems
    - integrated safe system designs
    - safe operating procedures
  - work in conjunction with existing infrastructure building activities
    - Sunline Transit Agency, Las Vegas Nevada, Fuel Cell Partnership
  - partner with the Fuel Cell partnership for this facility ?
  - ...

Strategic Issue

Operations, Maintenance, and Training (OMT)

- Develop procedures
- Train personnel

People / Activity	Refueling	Transport	Storage	Emergency
Customers	X			X
Mechanics	X			
Emergency personnel	X	X	X	X
Distribution		X	X	
Generation			X	

TO DO
Results by ‘03

Operations, Maintenance, and Training (OMT)

- RFP - ‘01 Develop a task force to identify OMT issues for cases (1 year)
  - include all relevant stake holders for each category in the working groups
    - for example: emergency personnel must be part of the working group that identifies OMT issues for refueling, transportation, storage, and emergency response.
  - Utilize the field verification facility (see detection and verification) for training of personnel (2+ years).
  - Iterate and improve on all documentation and procedures.

Overall
RFP '01

Education of John Q. Public

- Demonstrate H_2 as a safe energy carrier
- Put H_2 device in the face of every John Q. Public
- Establish a comprehensive task force to systematically identify safety issues WRT John Q. Public

Integrated System Design

- Establish a comprehensive task force to identify system issues WRT safety
- Design build and verify integrated systems - use ***verification facility***
  - establish strategic partnerships with existing infrastructure activities

Comprehensive Data Base

- Living WEB site technical tool - knowledge center

Detection and Verification

- Establish a ***field verification facility***

Operations, Maintenance, and Training

- Determine procedures and train personnel - use ***verification facility***

Safety Issues are invariant WRT various scenarios

Regulated scenario - high or low

- All issues identified apply
- Result is to increase John Q. Public's exposure to H_2

Free Market scenario

- All issues identified apply

Containers/Storage Focus Group

Consolidated lists of categories

- Safety
- Standards
- Performance
  - Container
  - System
- Education & training
- Storage technology

Technology categories

Category	Time	Weighting
5000 psi gas storage	Today	35%
10,000 psi	Medium	28%
Low-P adsorption	Long	23%
Liquid	Near	14%

5000 psi technology

Rank	Issue	Votes
1	Develop standards: facilitate w/ISO (container & components)	12
5	Training/education (develop)	2
7	Fast fill algorithms	0
2	Components: PRD, valves, regulators, manifolds	3
3	Allowable leakage & permeation (incl. Liner, joints, connections)	6
4	Material compatibility – corrosion, contaminants, odorants, embrittlement	4
6	Container optimization – vol., shape, wt., vehicle location	1

Low-Pressure adsorption technology

- Group did not want to rank these, because of the relative immaturity of the technology area. Instead, they considered this list to be a set of criteria for selecting a good adsorption material.
  - In/out efficiency & speed --different technology for “out”
  - Capacity -- weight criteria (>5.5%)
  - Cycle life; criteria for inspection
  - Cost
  - Environmental impact (material recycling)

SUMMARY OF HIGHER PRIORITIES (by category)

5,000 psi technology:

- Standards
- Components
- Leakage & permeation

10,000 psi technology:

- Container optimization
- Components
- In/out efficiency

Liquid technology:

- Container optimization
- Components
- Infrastructure

Low-Pressure adsorption (group did not prioritize of issues)

Refueling Station Focus Group

Master Rollout Plan

Develop strategy for the development and deployment of hydrogen infrastructure. Identify markets to focus infrastructure efforts.

- Focus on a small number of “early adopters” in CA, NV, AZ, NY and MA.
- Develop regional market penetration profiles.
- Geographically concentrate the refueling stations to fully utilize the infrastructure.
- Coordination between auto manufacturers and fuel providers to optimize timing of supply and demand.
- Coordination of purchases of government fleet vehicles with infrastructure installation.

The blueprint roadmap attendees suggested that this could be performed by a group similar to the Natural Gas Infrastructure Working Group, which has performed a similar effort related to NG vehicles.

Design Optimization

A coordinated, multi-project effort to develop functional, efficient, compact, expandable, cost-effective, and upgradable station designs utilizing a variety of technologies to serve fleets, and later, private vehicles.

- Skid mounted “Starter Pack”
- Expandable stations, including power generation/grid integration (for transit refuelers, where the buses will be refueled in the evening, it is possible to provide peaking power to the grid during the day. This may not be possible or profitable for a refueling station that is servicing private vehicles or some fleets, because it would need to provide fuel during the daytime)
- Differences between the design of fleet refuelers and private vehicle refuelers
- Cost reductions due to improved manufacturability
- Dispensing of on-site generated or delivered hydrogen
- Optimization for space and functionality
- Waste and emissions handling for on-site generation of hydrogen

Economics

These activities could also be performed by a working group, as discussed in the Master Rollout Plan.

- Identify subsidies that would lead to private funding
- Develop incentive programs that encourage conversation of fleets from diesel to NG to NG/H2 blends to hydrogen
- Develop cost targets that change with time as volumes increase and technology improves

Standardized Dispenser

- R&D on design of smart systems (vehicle feedback, nozzle design, receptacle design)
- Standardized interconnections
- Pressure-specific nozzles (low pressure connectors for ad/absorption systems, 3500 psi, 5000 psi, 10,000psi)

Accurate and Affordable Metering

- **Equipment R&D**
- **Training for Weights and Measures**
- **Customer interface**
- **Education (related to how to sell hydrogen - using which units of measure?)**

The NGV group has already addressed these issues for NG, and we could use their efforts as a model for the hydrogen-specific efforts.

Gas Purity/Composition Standards

- Equipment development
- Gas cleanup system cost reductions and technology improvements
- Odorant removal
- Compressor oil carryover
- Different “grades” of hydrogen for different vehicle types (ICEs can accept hydrogen with more CO2, CO, and other impurities that cannot be tolerated by a fuel cell vehicle)

Training and Education

- **Emergency response training**
- **Vehicle maintenance and repair training**
- **Non-fuel-system repairs (i.e. radio installation) - what they need to know when working on a hydrogen vehicle**

The success of any one particular scenario that Sig presented as the foundation for the breakouts has little effect on the list of needs. The group thought that the design difference for stations used for bus fleets versus LD fleets or private vehicles were primarily due to the rate of delivery of hydrogen, the utilization factors, and the day/night fueling cycle differences.

Codes and Standards Focus Group

Focus Group Summary

- 5 Key categories identified in ranking process
  - Coordination/Synchronization of codes and standards efforts
  - Lack of suitable installation standards
  - Lack of standardized product/storage standards
  - Technical basis needed for codes and standards
  - Education

Coordination and synchronization of codes and standards efforts

- Groups are not coordinated-- leads to gaps/ overlaps
- Key players are not adequately represented
- Little coordination among North America/ Japan
- Difficult to translate ISO trends into national trends

Lack of Suitable Installation Standards

- Hydrogen Stations
- Maintenance Facilities
- Pipelines
- Terminals

⇨ Generally, lack of suitable installation standard exists

⇨ No standards exist for delivery of Hydrogen at retail/home level

⇨ No experienced personnel to undertake installations

⇨ Without appropriate guidelines, costs and lead times become major issues

Lack of Standardized Product/Storage Standards

- Technology in a state-of-flux
- Liquid (cryogenic), gaseous (various pressures), Hydrogen Blends (various compositions), and hydrides

<u>Caveat</u>: Development of standards at too early of a stage can impede technology development.

Technical Basis for Codes and Standards

- Need to identify issues
- Need for credible organizations to conduct proper evaluations
- Need for verifiable data
- Lack of real world events compound problem

Education

- Education needed for code officials (permitting, inspectors)

Thoughts on Scenarios

- From codes and standards perspective, focus on centralized infrastructure until:
  - FC Cost < $50/kw
  - Storage system considered safer than gasoline
  - Codes and standards are in place
- Centralized infrastructure would be associated with:
  - Free market yielding bus applications
  - Fleet applications